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ABSTRACT

This paper presents four philosophies of science teaching for teachers to use that encourage optimal learner achievement. Information is provided on an experimentalist or problem solving approach, an idealistic or subject-centered science curricula, a decision-making approach, and criterion-referenced procedures for learning. Two psychologies of learning--behaviorism and humanism--are also reviewed. This paper suggests an instructional approach that includes lessons modeled using all four of the philosophies discussed. (DDR)

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Teaching Science as Inquiry

by
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TEACHING SCIENCE AS INQUIRY

Science teaching must reflect change within a curriculum that stresses assisting pupils to attain optimally. Objectives, learning opportunities, and appraisal procedures in science need to be relevant and updated to incorporate National and state standards. Units of instruction in science should stress inquiry, motivate pupils, and encourage high levels of interest. Educational philosophies and psychologies used in teaching- learning situations by the teacher must guide pupils to develop an inward desire to learn.

Philosophy of Science Teaching

The science teacher needs to have a wide repertoire or means of assisting pupils to achieve optimally. There are diverse educational philosophies for teachers to use that encourage optimal learner achievement.

First, a problem solving approach may be used. Inquiry learning is highly salient here. Ideally, pupils with teacher guidance need to identify a problem within the framework of an ongoing science unit of study. The problem must be clearly stated. Learners might then brain storm possible answers to the problem. Value judgments should not be made on responses given by pupils. The consequences or results of each brainstormed answer must be evaluated after the brainstorming session has been completed. A variety of manipulative, pictorial, and abstract materials should be used here. Science experiments may be at the heart of testing each response or hypothesis. Responses are then modified changed, or refuted as a result of the tests. John Dewey and other experimentalists emphasized problem solving strongly in their philosophy of experimentalism. Committee endeavors and cooperative learning are stressed in the problem solving science curriculum.

Experimentalists believe the science curriculum should be as closely related to the real world of society as possible. School and society are not separate but integrated entities. To emphasize problem solving, the science teacher must provide a learning environment that is

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stimulating and arouses pupil interests. Hopefully, the interests of learners will lead to problem identification. The goal of the science teacher is to have learners select relevant problems. The teacher becomes a resource person, guide, and helper, rather than one who lectures and presents content deductively to pupils. Thus learners need assistance in brain storming, locating reference sources, and attaining hypotheses as means of inquiry learning.

With pupils being heavily involved in selecting problems and strategies to solve each problem, a psychological curriculum is in evidence since each learner is heavily involved in sequencing or ordering his/ her own experiences. The learner himself/ herself tends to order experiences in a problem solving approach of teaching, according to educational psychologists. Pertaining to John Dewey's philosophy of experimentalism, Meyer (1949) wrote the following:

All this, of course, depends in no small way upon thinking. For Dewey, however, thinking becomes significant only when applied to life's situations. It is, he has said, "an instrumentality used by man in adjusting himself to the practical situations in life." Or to phrase it more simply, human beings think in order to live. Because to this stimulus, which has its basis in biology and sociology, it is impossible- it is absurd-- to interpret life in a systematic and abstract way. Since, moreover, Dewey holds that life is in constant flux, it is impossible to solve problems with any degree of finality for the problems of tomorrow will be different from those of today.

As for the problem of knowledge, Dewey believes that knowledge is experience and that true experience is functional. What is this thing for? What is its use? Is a coal mine a physical deposit or does it have function? And if so, what is it? Such are the questions that help give meaning to one's experience; but such questions cannot be answered without antecedent action. Action must precede knowledge. Whatever knowledge we possess has resulted from our activities, our efforts to survive, to obtain food, shelter, and clothing. Only that which has been organized into our disposition so as to enable us to adapt our environment to our needs and to adapt our aims and desires to the situation in which we exist is really knowledge.

A second philosophy of education to stress is a subject centered science curriculum. Here, the science teacher must select and teach vital facts, concepts, and generalizations to pupils. Inquiry learning emphasizing critical and creative thinking, explanations, and vital discussions are methods of instruction used to teach learners. Intellectual development is a major objective of science instruction. Mind is real and needs challenging subject matter to encourage mental development. Cognitive objectives should be emphasized primarily. However, affective goals are also salient as they assist pupils to attain cognitive ends of science instruction. It is important to secure pupils interest in science, but each learner must also will to learn. Tasks in life are interesting as well as those that do not stress interest. Thus, the pupil must develop a will to achieve, attain, and develop well intellectually.

Subject centered approaches in teaching science emphasize the abstract instead of the concrete and semiconcrete facets of learning. The concrete (use of real objects, excursions, realia, and experiments), and the semiconcrete (illustrations, videotapes, video-discs, computers with diverse capabilities, among other audio visual aids) should be used as learning opportunities to assist pupils to achieve the abstract. Thus objectives in teaching science need to stress the abstract in subject matter to be acquired as well as higher levels of cognition in ongoing units of study in science. The teacher largely determines which objectives and learning activities pupils are to pursue sequentially. Thus a logical science curriculum is being emphasized, according to educational psychologists. Ediger (1995) wrote:

Idealists are very academic and rigorous in the teaching of subject matter. They emphasize cognitive objectives much more so than affective (attitudinal) or psychomotor (use of muscles and eye-hand coordination) in teaching-learning situations. Meaning, understanding, and depth learning of subject matter are important to idealists. Vital subject matter, carefully selected, needs to be taught to students. The student in acquiring subject matter in ongoing lessons is to move form the finite (limited) to the infinite Being. Ideas are important to attain in

an idealist's curriculum. The ideal is also salient to achieve in terms of moral standards and values.

The teacher emphasizing idealism as a philosophy of education stresses the selection of subject matter for student achievement which assists forming vital concepts and generalizations. Objectives of instruction need to reflect worthwhile concepts and generalizations. Depth teaching of specifics assists students to form and develop universal ideas. The use of behaviorally stated objectives for instruction would be frowned upon by the idealist teacher. Content would become too fragmented with the realist's position of testing and measuring reflecting measurably stated objectives. Rather, the idealist in emphasizing an idea centered curriculum desires that students relate subject matter acquired so that intense learning transpires. Thus if students are studying causes of World War II, each cause would be studied thoroughly and not merely listed. Causes come in sequence and are complex to appraise. Viewing and analyzing each cause takes time. After analyzing, relating, or synthesizing ideas take time in order to emphasize intensity, not survey teaching. Students are to be evaluated in progress as to how much vital subject matter has been acquired.

The use of the mind or intellect is salient for students to utilize in analyzing and synthesizing subject matter knowledge. Mental development is stressed as students learn, achieve, and develop.

Implications from idealism as a philosophy of education for the curriculum include the following:

1. intellectual, not attitudinal, nor psychomotor, goals come first in teaching-learning situations.
2. quality textbooks, workbooks, and selected audiovisual materials which aid in intellectual development should be used as learning activities to achieve stated goals for students.
3. evaluation techniques should stress appraisal of vital subject matter acquired by students.
4. depth teaching of subject matter is salient to guide learners to attain vital facts, concepts, and generalizations. Survey approaches are not acceptable.
5. the will of the student is needed to attain worthwhile subject matter. Interest of students, alone, is not adequate for students to achieve, attain, and develop well. Students must want to learn.
6. students need to achieve vital subject matter to prepare for the future life of an adult. Education is preparation for adult responsibilities, not present day situations in being a child.
7. learners need to develop from a finite (limited) being toward the Absolute or the Infinite (unlimited being). The Absolute may also be referred to as God.
8. a quality general education program, consisting of vital content from major academic disciplines, is a must for all students.

A third philosophy of teaching emphasizes pupils being heavily involved in decision making in terms of choosing objectives, learning opportunities, as well as evaluation procedures. The science teacher needs to set up more stations with quality tasks than what any one pupil can complete. The pupil may then select sequential tasks to complete. Those tasks not having perceived purpose may be omitted by the learner. The teacher must choose relevant learning opportunities for pupils to select. Inquiry, problem solving, as well as critical and creative thinking tasks, are vital learning activities for pupils at each station. Careful consideration must be given to the worth of each station and task. The interests of pupils need to be cultivated in the science curriculum. The pupil is the chooser of which tasks to pursue and complete. The science teacher is a guide and stimulator but not a dispenser of information.

The attitudinal dimension is very important to develop within pupils when they select that which is vital to attain. Learners need to learn to make choices and decisions. Life itself consists of making choices within the framework of being openended and possessing freedom. In the science curriculum, pupils too need to make choices in which coercion is kept to a minimum. A decision making philosophy stress the learner being responsible for choices and completions made. Decision making is a skill and an attitude that pupils should learn due to its tremendous value presently and in the future for pupils.

With pupils being heavily involved in choosing sequential tasks to complete, a psychological curriculum is then in evidence due to pupils sequencing their very own activities in the science curriculum.

Pertaining to existentialism and pupil choices in the curriculum, Ozman and Craver (1990) wrote:

It is interesting that most existentialists and phenomenological philosophers have had lengthy and rigorous educations...Most of them taught at one time or another, usually in a university setting. They have been primarily concerned with the humanities and have written exclusively in the genre. Through the humanities the existentialists have tried to awaken modern individuals to the dangers of being swallowed by the megalopolis and runaway technology. This seems to have taken place because the humanities contain greater potential for introspection

and the development of self-meaning than other studies.

The humanities loom large in an existentialists curriculum because they deal with the essential aspects of human existence such as the happy, the absurdities as well as meaning. In short, existentialists want to see humankind in its totality- the perverted well as the exalted, the mundane as well as the glorious, the despairing as well as the hopeful, and they feel that the humanities and the arts do this better than the sciences. Existentialists, however do not have any definite rules about what should comprise the curriculum. They believe that the student-in-situation making a choice should be the deciding factor.

Although existential phenomenologists have been interested in understanding the lived experience of the learner than in the specific content to be learned, some of them have given attention to curriculum organization and content. The tendency, however, is to view curriculum from the standpoint of the learner rather than as a collection of discrete subject matter.

A fourth philosophy of education for science teachers to follow is a criterion referenced (CRT) procedure of instruction. Here the teacher needs to write measurably stated objectives for pupil attainment. These objectives are always written prior to teaching pupils. Each objective is written in as precise a manner as possible. Ideally there is no leeway in interpreting what will be taught when examining any one measurably stated objective. The science teacher can measure after instruction if a learner has or has not achieved a measurably stated objective. The CRT measures against the measurably stated objectives to ascertain pupil achievement.

Science teachers may even announce to pupils what they are to learn as a result of instruction. Learners then might possess security in terms of what they are expected to achieve as a result of teaching and learning. Learning activities selected by the teacher to assist pupils to achieve must be aligned with the measurably stated objectives. These activities must be selected on the basis of guiding each pupil to achieve objectives. A logical curriculum is in evidence if the teacher chooses sequential objectives for pupil attainment as well as learning opportunities that are sequentially arranged so that pupils can experience success in learning.

Since teachers determine the sequence of objectives and learning

opportunities for pupils to pursue, a definite logical curriculum is being stressed by science teachers. The teacher then attempts to arrange the order of objectives and activities to guide optimal pupil achievement. Pertaining to realism, Bowyer (1970) wrote the following:

We have noted that there are different forms of naturalism and of idealism . The same is true of realism, which makes it difficult to define the realist point of view. One element that the various forms of realism do have in common is a rejection of the idealist theory of knowledge that the various qualities of experience depend upon a knower for their existence. Realists believe the universe is composed of real entities that exist in themselves. These entities can be known, and their existence is not dependent upon a knower or perceiver. Although realists can agree on this point, they do not all agree when they attempt to build a metaphysical system. Here, their views range from pluralism to dualism to monism.

The realist epistemological views include epistemenological monism where it is held that objects are presented in consciousness, and epistemological dualism where objects are thought to be represented. The monist defines mind as a relation between the organism and an object, while the dualists identify mind more closely with the organisms. Realists do have a tendency to view the world as the mechanism described by the physical sciences. and they generally believe in determinism, in orderliness in the universe, and the objectivity of science. The unifying thesis of realism is that knowledge is thought to have a universal character and comes to man through his sensory capacity. The realists have a confidence in their assertions about reality and value which is most discerning to pragmatists.

Recent Psychologies of Learning

B.F. Skinner (1904-1990) was very instrumental in emphasizing S-R theory of instruction. With S-R theory in teaching science, Skinner advocated programmed learning for pupils. Programmed learning can take place either in textbook or computer/software form. Here, pupils move forward very slowly from the simple to that which is gradually more complex. Pupils then respond to a logical sequence developed by the programmer. Thus the pupil reads a small amount of content, responds to a completion item, and checks his/her response with that provided by the programmer. If the pupil responded correctly, he/she moves on to the next sequential item. If the learner responded incorrectly, he/she tries a different response. If correct, the learner also moves on to the

next sequential item. The sequence is the same each time with read, respond, and check. If the learner is correct, he/she is rewarded and reinforced for giving the correct answer to the completion item as provided by the programmer. Skinner believes that a programmer can always put in another item should the pupil taking the program in the pilot study miss out in a sequential item. A quality program should make for a ninety per cent correct pupil response per item for each in the pilot study. The pilot study involves conducting experiments to find out where weaknesses lie in the program. If too many learners, miss an item, perhaps an additional step needs to be put in where these pupils responded incorrectly. Poorly written items are taken out or modified so that responses can be made based on clarity within that step of learning. I have observed selected well written programs in science units of study which reflect the thinking of B. F. Skinner. Pertaining to programmed learning, Harris and Sipay (1985) wrote the following:

Programmed materials are designed so that the user (1) encounters a series of small steps on which success is very likely (2) is involved in the learning process through actively responding (3) receives immediate feedback as to the correctness of each response. In theory, programmed material should greatly facilitate individualized instruction because they allow each student to work almost independently with material suitable for his or her needs, proceeding at a pace commensurate with ability and interest.

Ediger (1997) wrote the following pertaining to programmed instruction:

The programmer decides upon the objectives for each program. Also, the sequential activities and appraisal procedures are determined by the programmer. There is basically no input from pupils or from teachers in terms of objectives, learning activities, and evaluation procedures when utilizing programmed materials.

Advantages given for using programmed learning include the following:

1. each learner may pace his/her own optimal speed of learning. No two pupils need to be at the same or similar level of achievement.
2. learners know immediately if they are right or wrong in responses made.
3. rarely do learners make mistakes in quality programmed

materials. The error rate is five to ten per cent in field tested programs.

4. reinforcement is possible in field tested programmed items. Thus an involved learner might experience rather continual progress.

5. sequential progress is made in small steps rather than covering content in terms of a large scope at a time.

Disadvantages given in emphasizing programmed learning include:

1. programmed learning may not harmonize with learning styles of selected pupils.

2. step by step learning -- read, respond, and check-- does not harmonize with expectations of life in society. Life in society is not programmed.

3. programmed materials tend to deemphasize the utilization of the concrete (reality), and semi-concrete (pictorial form) materials. Abstract content tends to be rather heavily emphasized in programmed materials.

4. selected pupils may not perceive interest and purpose in the programmer choosing objectives, learning activities, and evaluation procedures.

5. small sequential steps in learning may be too finite or limited to meet personal needs of gifted and talented learners.

The influence of programmed learning and the thinking of B. F. Skinner has had wide influence in educational thought. There still are programmed books available on many topics in book form as well as in computer packages. Perhaps, the strongest influence of Dr. Skinner is in the use of behaviorally stated objectives in teaching. These objectives are very precise and are written prior to instruction. A pupil as a result of instruction either does or does not achieve any single objective. Thus, it is possible to measure if a pupil has been successful in goal attainment. Leaning activities selected by the teacher align with the stated objectives. The evaluation procedures also are aligned with the measurably stated objectives. Objective results from pupils are in evidence from instruction, regardless of who does the evaluating. Relating B. F. Skinner's thinking and that of the behaviorally stated objectives movement, the following writing will assist in clarifying the two (Morris and Pal, 1976):

As Skinner pointed out several times, the most important task of the teacher is to arrange the conditions under which desired learning can occur. Considering the fact that teachers are expected to bring

about changes in extremely complex behavior, they should be specialists in human behavior. Effective and efficient manipulation of the multitude of variables affecting children's intellectual and social behaviors cannot be accomplished by trial and error alone, nor should such work be based solely on the personal experiences of the teacher, since this covers only a limited range of circumstances. Consequently, a scientific study of human behavior is vital in the improvement of teaching, because it provides us with accurate and reliable knowledge about learning and leads us to the development of new instructional materials, methods, and techniques. Similarly, an empirical analysis of the teaching process is essential, for it clarifies the teacher's responsibility through a series of small and progressive approximations. thus facilit ting a more effective evaluation.

The measurably stated objectives movement, also called behaviorism as a psychology of learning, emphasizes a rather closed system of instruction. The objectives are predetermined and may be announced to pupils for each end to be stressed, as the need progresses. the learning activities and the evaluation techniques harmonize or align. Many educators believe that this alignment optimalize learner achievement in teaching and learning situations.

With this close alignment , little room is left for pupils to raise questions that they deem to be relevant and vital.

Humanism in the Science Curriculum

Toward the other end of the continuum, humanism, as a psychology of learning stresses heavy pupil involvement in selecting objectives, learning opportunities, and appraisal procedures. the pupil here is the focal point of instruction. Learners are to involved in sequencing their own experiences; this emphasizes a psychological science curriculum whereas the behaviorally stated objectives psychology advocated a logical sequence for pupils whereby the teacher orders objectives for pupil attainment. Pertaining to humanism and existentialism, Ediger (1996) wrote:

Existentialists believe that one exists and then purposes need to be found or developed. The individual self then determines his/her own goals in life. There are no absolutes or guidelines in life to choose what is right and what is good. Each person must select and make decisions. To avoid making decisions is to lack being human. The choice then is to

go along with the crowd. However, to be human involves making decisions.

The only broad criterion for existentialists to follow in choosing is to make moral decisions in a complete atmosphere of freedom. Others should definitely not decide one's destiny. One did not ask to be born and yet each person must make authentic decisions.

Moral decisions are difficult to make. An environment of awe exists in making authentic decisions.

Which objectives, learning activities, and evaluation procedures should be inherent in an existentialist curriculum? Existentialists believe in each person choosing objectives. In the school setting, the goals may be selected by learners with teacher guidance within the framework of an open-ended curriculum. The teacher needs to select ends, means, and evaluation procedures which stress the importance of pupils becoming increasingly responsible for personal freedom. The teacher should definitely not be a policeman. Rather, teachers realize their role as providing for an open environment in order that the learner may select sequential experiences...

Each decision made in life involves personal decisions in reaching a goal or goals... Each person makes or breaks himself or herself. No other person or being is responsible for consequences of decisions made. Blaming others for what happened in life is meaningless, according to existentialists. Each person needs to learn to accept responsibilities for thoughts, deeds, and actions.

The humanist or existentialist science curriculum may be implemented in several ways. One approach is to use learning centers in the school/classroom setting. I have observed the following learning centers pertaining to the science unit "The Changing Surface of the Earth," from which pupils may select sequential tasks to complete:

1. a reading center
2. an art center
3. a drama center
4. a writing center
5. an audio-visual center
6. a computer and software center
7. a music center
8. a model making center
9. a problem solving center
10. an experiment center

Each pupil in a classroom may select which center and which task to work on. There are more tasks at each center than what any one child can complete. Learners may then choose what to work on and what to omit in a humanistic science curriculum. The individual pupil determines

sequence or order of which tasks to pursue and which to omit. Purpose for learning then reside within the pupil. Examples of which materials will be at a learning center and the kinds of tasks or learning activities that will be in evidence may be illustrated with the first center mentioned above -- a reading center. Here, a variety of library books on the unit title and on diverse reading levels need to be in evidence. A pupil chooses a book to read and may complete as many of the following tasks at this center as individual purpose dictates:

1. write a summary covering content read.
2. make a model of inherent subject matter read, such as a model voicano.
3. draw a picture of folding and faulting.
4. write an additional page for the library book read.
5. identify a problem dealing with changes on the earth's surface and use various reference sources to locate information for solving the problem.

Pupils individually make choices sequentially as to what to learn and the means of learning. Tasks can relate to choosing to work by the self or with others. If too many work at one center, the teacher may make a rule as to the optimal number of pupils that may work at any one center. The science teacher here is a guide or motivator of pupils to stay on task and complete satisfactorily what has been selected as learning activities. The pupil may even plan with the teacher what to work on if greater purpose is perceived in working on something else than what is at any of the centers.

Humanists advocate that pupils reveal authentic behavior, not facades. to be authentic, the pupil needs to reveal more of the real self. Trust in communicating with others is important. Humans have tremendous worth and value. Being authentic and trusting others in a positive relationship is relevant to humanists.

Many studies currently made stress the importance of multiple intelligences. Sternberg (1997) emphasizes that in a Yale University

study, intelligence has analytical, creative, and practical aspects. He presets the following model for science in four categories:

Memory--name the four types of bacteria.
Analysis--analyze the means the immune system uses to fight bacterial infections.
Creativity--suggest ways to cope with the increasing immunity bacteria are showing to antibiotic drugs.
Practicality--suggest three steps that individuals might take to reduce the likelihood of bacterial infection.

In any lesson and unit of study, the science teacher may emphasize these four categories of instruction. Pupils need to achieve at higher levels of cognition than the memory level. Learners will then reveal in different ways what has been learned in the analysis, creativity, and practicality levels. Intelligence then is not a single score nor a single way of indicating what has been learned. Sternberg (1997) goes on to say:

By exposing students to instruction emphasizing each type of ability, we enable them to capitalize on their strengths while developing and improving new skills. This approach is also important because students need to learn that the world cannot always provide them with activities that suit their preferences. At the same time, if students are never presented with activities that suit them, they will never experience a sense of success and accomplishment. As a result, they may tune out and never achieve their full potential...
Success in today's job market often requires creativity, flexibility, and a readiness to see things in new ways. Furthermore, students who graduate with A's but cannot apply what they have learned may find themselves failing on the job.

Creativity, in particular, has become even more important over time, just as other abilities have become less valuable. Fro example, with the advent of computers and calculators, both penmanship and arithmetic skills have diminished in importance. some standardized ability tests, such as the SAT, even allow students to use calculators. With the increasing availability of massive, rapid data retrieval systems, the ability to memorize information will become even less important..

This is not to say that that memory and analytical abilities are not important. Students need to learn and remember the core content of the curriculum, and they need to be able to analyze-- to think critically about--the material. But the importance of these abilities should not be allowed to obfuscate what else is important.

In a pluralistic society, we cannot afford to have a monolithic conception of intelligence and schooling, it's simply a waste of talent .

And as I unexpectedly found in my study, it's no random waste. The more we teach and assess students based on a broader set of abilities, the more racially, ethnically, and socioeconomically diverse our achievers will be. We can easily change our closed system-- and we should. We must take a more balanced approach to education to reach all of our students.

Sternberg believes strongly that pupils individually are not permitted to indicate what has been learned in diverse ways. It is true that pupils so often are asked to show achievement through testing, generally through pupils taking multiple choice tests. Thus verbal approaches are used to ascertain what pupils individually have learned. This is limiting in that there are many other means of revealing achievement. Dr. Howard Gardner (1995) has determined there are at least seven intelligences, according to his research; these are verbal-linguistic, interpersonal, intrapersonal, musical, spatial, bodily-kinesthetic, and logical mathematics. Pupils may show similar strengths, but not necessarily in the same ways or to the same extent over time. With multiple intelligences, pupils learn in diverse ways and are interested in different subject matter in the academic arena. Learners then reveal their strengths and weaknesses in what has been learned in a variety of ways, not one way only such as in verbal testing using multiple choice items. Thus, the pupil who is strong in the verbal arena will reveal differently what has been learned as compared to the one endowed with musical intelligence. Too frequently, the emphasis has been upon verbal approaches to assessing pupil achievement and yet there are numerous other ways to indicate intelligence, as Dr. Gardner has indicated in multiple intelligences theory. Hatch (1997) wrote:

Such a view of intelligence is reflected in programs and practices that seek to determine which areas young children show the greatest strengths. Children who do well on tasks in a particular area--storytelling or reporting, athletics or dance, drawing or building--are broadly labeled as having strengths in linguistics, bodily-kinesthetic, or spatial realms, respectively.

Such an approach, however, implies that children have a reservoir of talent in a variety of activities, shown consistently over a period of time. It suggests that there are more intelligences, but does not necessarily call into question assumptions about the nature, display,

and development of intelligence.

In Summary

Science teachers need to develop a philosophy and psychology of instruction that optimalize learner attainment. Pupils differ from each other in many ways including methods and procedures of acquiring relevant facts, concepts, and generalizations. A careful study and implementation of a worthwhile philosophy and psychology of learning might well assist each pupils to learn as much as possible.

To stress science as inquiry in harmony with National Standards, the writer emphasizes what he believes to be best from each school of thought discussed above. These are

1. a problem solving science curriculum in which pupils with teacher guidance identify and solve relevant lifelike problems.

2. a subject centered science curriculum emphasizing pupils attaining higher levels of cognition in achieving salient facts, concepts, and generalizations.

3. pupil selection from among alternatives of tasks perceived to be purposeful. Tasks at different stations should reflect science as inquiry.

4. measurably stated objectives which reflect National Standards in a predetermined science curriculum. Precise objectives are then selected prior to instruction for learner attainment. A carefully designed science curriculum may then be in evidence. The content obtained should be inherent in science as inquiry teaching and learning.

Pertaining to the psychology of learning in science, pupils should achieve quality sequence. Interest, purpose, and meaning are important concepts to stress in teaching science in ongoing lesson plans and units of study.

With multiple intelligences theory, pupils do learn in different ways and through diverse methods of instruction. Learners individually do possess their favorite means of learning and achieving. There are numerous methods of revealing what has been learned.

The science teacher then needs to have pupils participate in a variety of learning opportunities and have them indicate achievement

using diverse procedures to provide for different learning styles possessed. The following learning opportunities are available for pupils in the science curriculum:

1. hands on approaches in learning.
2. experiments and demonstrations.
3. field trips and excursions.
4. problems solving experiences.
5. reading from basal texts, library books, and science encyclopedias.
6. viewing video tapes, video disks, films, and filmstrips.
7. discussing, interviewing, dramatizing, and pantomiming.
8. writing poems, plays, outlines, summaries, diary entries, log entries, journal entries, and stories.
9. making dioramas, collages, bulletin board displays, murals, models, and equipment for science experiments.
10. using technology such as computer packages, the word processor, internet and world wide web, and calculators.

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